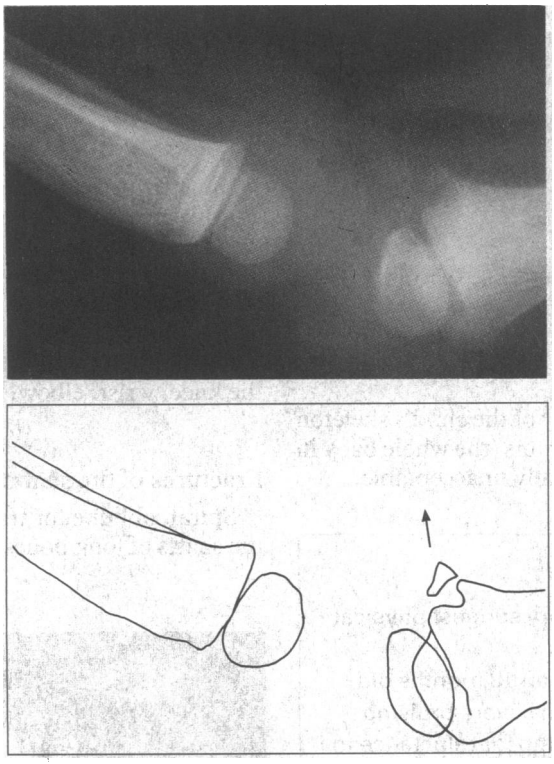
FRACTURES

C J Hobbs



Metaphysial (corner) fracture of lower end of femur in a child of 15 months, who was swung by the legs and hit head against a wall

Fractures are among the most serious injuries sustained after physical abuse. They may occur in almost any bone and may be single or multiple, clinically obvious or occult and detectable only by radiography.

Prevalence

In one study of physically abused children more than half of the children (58%) were under 3 years old and they sustained most of the fractures (94%). In contrast, accidental fractures occur more commonly in children of school age.

The proportion of children presenting to hospital with fractures resulting from physical abuse rises to a maximum during the first year of life, when it may be as high as a half. A great deal of suspicion is required at this age. Most accidental fractures in infants and toddlers result from falls, although fractures are uncommon in falls of under a metre.

As early detection improves the proportion of children with fractures who are identified as having been physically abused falls from 50% to 10% or less. Most children with serious injury have suffered minor injury or shown other signs of abuse that have not been recognised or acted on by professionals in contact with the child.

Detecting fractures due to physical abuse

Children whose fractures are the result of an accident present crying excessively, with swelling or bruising, and are reluctant to use the affected part—for example, to put weight on a leg.

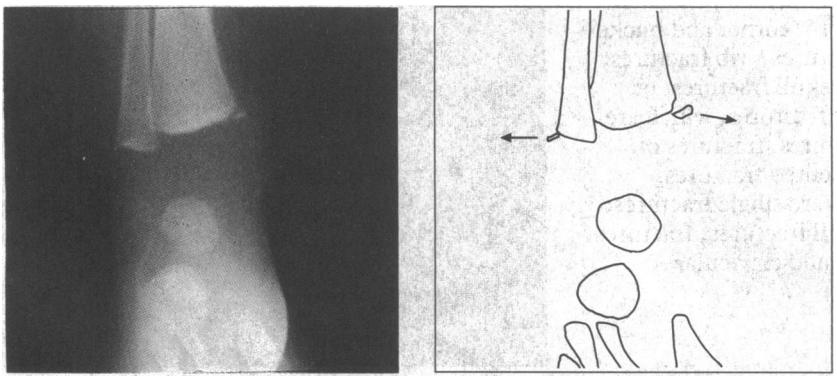
Some fractures caused by physical abuse are detected only by radiology because the fracture may be old, the physical signs having regressed; the site may be hidden—for example, the ribs, pelvis, or skull—and the parents will not have drawn attention to the possibility of injury.

Important patterns

Six important patterns are seen in fractures caused by physical abuse. These are (*a*) a single fracture with multiple bruises; (*b*) multiple fractures in different stages of healing, possibly with no bruises or soft tissue injuries; (*c*) metaphysial-epiphysial injuries, which are often multiple; (*d*) rib fractures; (*e*) the formation of new periosteal bone; and (*f*) a skull fracture in association with intracranial injury.

As with all forms of physical abuse a careful history and examination and appraisal of the

Distal metaphysial chip fractures of lower end of tibia and fibula in abused infant



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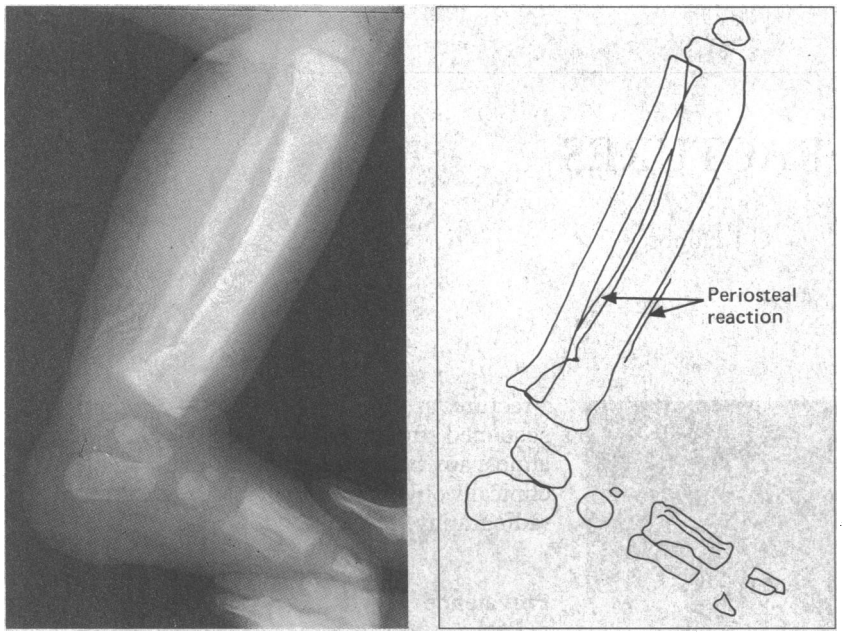


Distal non-displaced fracture of lower shafts of tibia and fibula in abused child of 6 months, with evidence of periosteal reaction along tibial shafts. Fracture is probably 10-14 days old. Other injuries included multiple rib and complex skull fractures

family potential for child abuse provides the framework for diagnosis.

Skeletal survey

The radiographic survey of the child's skeleton must be complete. Babygrams (the whole baby in one radiograph) are generally unacceptable.

Consider skeletal survey

- When injury or history suggest physical abuse
- In all children less than 18 months old
- In older children with severe bruising
- For localised pain, limp, or reluctance to use arm or leg
- When history of skeletal injury
- In children dying in unusual or suspicious circumstances.

Specificity of radiological findings

No lesion is absolutely pathognomonic of physical abuse but some carry higher specificity than others.

High specificity findings are metaphysial or epiphysial fractures, or both (corner and bucket handle fractures, chip fractures); rib fractures; multiple or wide complex skull fractures, or both; scapular and sternal fractures, which are uncommon; multiple fractures; fractures of different ages; and unpresented fractures.

Low specificity findings are single fractures; linear, narrow parietal skull fractures; fractures in the shaft of long bones; and clavicular fractures.

Rib fractures

Rib fractures are usually occult and detected only by careful radiology, unless there is history of direct trauma to the rib cage—for example, a road traffic accident—or bone disease. Rib fractures are specific for physical abuse in young children.

Cardiopulmonary resuscitation does not cause rib fractures in this age group.

Rib fractures are often multiple and bilateral and occur posteriorly. They are caused by thoracic compression, which often occurs with shaking and from kicks or blows in older children. Recent fractures are difficult to see but are more obvious later when callus forms as beaded shafts after about 10-14 days.

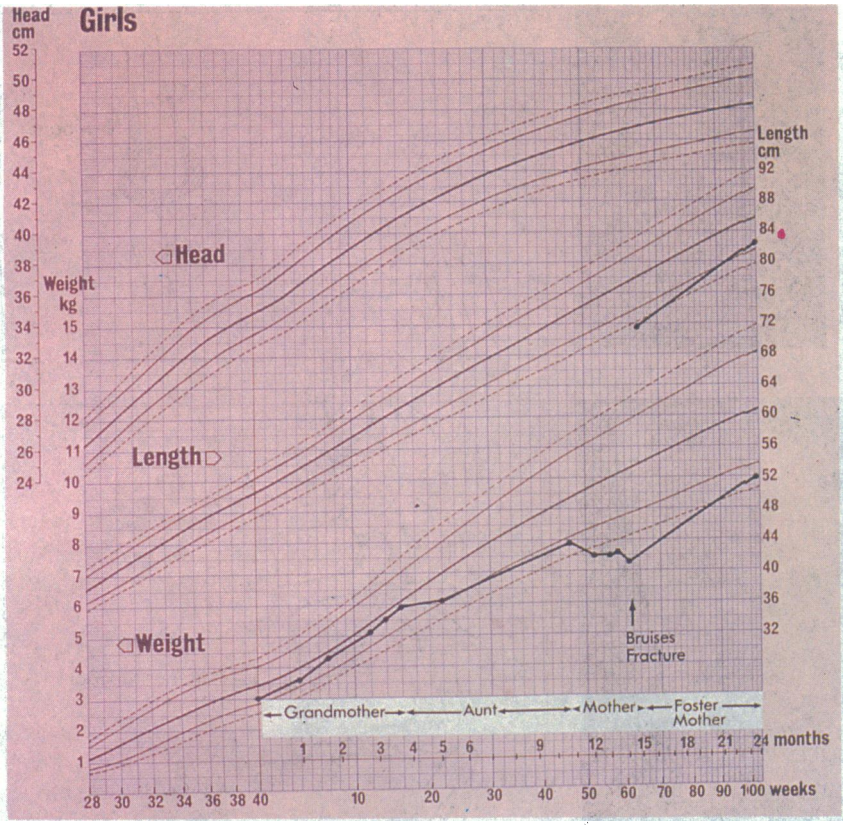
Metaphysial and epiphysial fractures

Metaphysial and epiphysial fractures are the classic injuries of physical abuse. Fragments of bone become separated from the ends of long bones either as a chip or as a whole plate. Such injuries arise from acceleration and deceleration as the infant is shaken by the body, arms or legs. The forces of pulling and twisting applied to the weak metaphysial areas of bone disrupt a fine layer of new trabecular bone close to the junction with cartilage. In epiphysial lesions the injury occurs in the zone of hypertrophic cartilage with few radiological signs initially. The usual sites are the knee, wrist, elbow, and ankle.

Fractures of the shafts of long bones

Spiral, oblique, or transverse fractures arise in the shafts of long bones from indirect trauma—

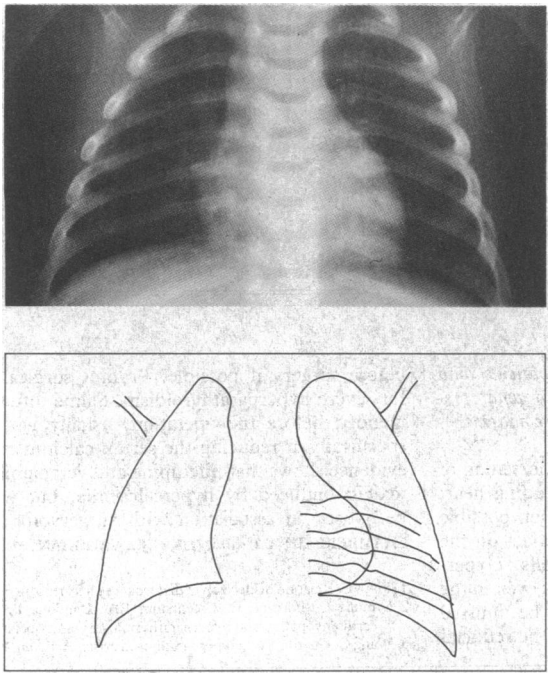
Mid-shaft fracture of radius and ulna in 14 month old girl with old bruising to her thigh and failure to thrive. Fracture in itself carries little specificity for physical abuse, but bruising and growth chart (overleaf) greatly increase likelihood of physical abuse. Cohabiting boyfriend of girl's mother admitted swinging child by arm



Growth chart of 14 month old girl with fractured tibia and fibula in case described overleaf. Pattern of failure to thrive developed from age of 4 months, when care was transferred to an aunt, and worsened when natural mother took over care at about 12 months. Catch up in length and weight were seen in foster mother's care. Children may react to changes in carer by developing behavioural difficulties, often centred on feeding, which may trigger violent responses from parents

for example, being swung by the arms—or direct trauma—for example, being hit across straightened arms with an iron bar, which causes symmetrical transverse fractures of the lower third of both radii.

Spiral fracture of the humerus was found to be significantly more common in physical abuse than in accidents in one study, but all types of fractures can arise either from physical abuse or an accident. Only the history or presence of other injuries will help differentiate between the two.



Posterior healing rib fractures of left sixth, seventh, and eighth ribs behind cardiac shadow in abused infant. Presence of callus and unclear fracture line suggests fractures are at least two weeks old

Spinal injury

Spinal injury in physical abuse usually results from hyperflexion-extension injury with damage to several consecutive levels. Defects in the lucency of the anterior superior edges of the vertebral bodies, often in the lower thoracic and upper lumbar region, with narrowed disc spaces are characteristic. Multiple spinous process fractures are also described. Spinal cord injury may follow dislocation or subluxation.

Formation of new periosteal bone

Injury to an infant's developing long bone often results in subperiosteal haemorrhage, which raises the periosteum from the shaft while maintaining its firm attachment to the epiphysis. This process usually takes 10-14 days to appear, and radiography may yield negative results initially. The finding may also point to an underlying fracture that is not easily visualised.

Such injuries probably arise when arms and legs are grabbed, pulled, or used as a handle for shaking the child. Trauma must be distinguished from other causes—namely, infection, Caffey's disease, vitamin A intoxication, leukaemia, and certain drugs—but all of these are far less common than physical abuse.

Dating fractures

The dating of fractures is of obvious medicolegal importance. Fractures heal in distinct stages, which can be detected radiographically, according to a set time scale, shown in the table. The table gives peak times; sometimes the earliest changes are seen a few days before this.

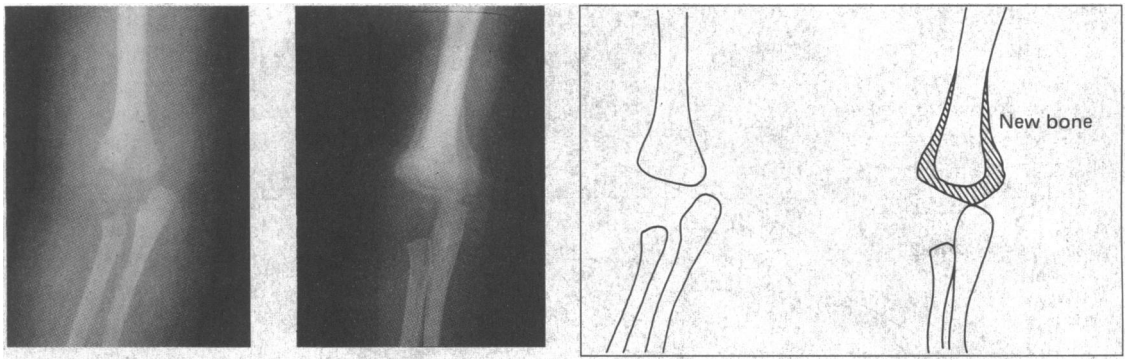
Resolution of soft tissue change	4-10 days
Periosteal new bone formation (earliest sign)	10-14 days
Loss of fracture line definition	14-21 days
Soft callus	14-21 days
Hard callus	21-42 days
Remodelling	1 year

From: Kleinman PK. *Diagnostic imaging of child abuse.* Baltimore: Williams and Wilkins, 1987.

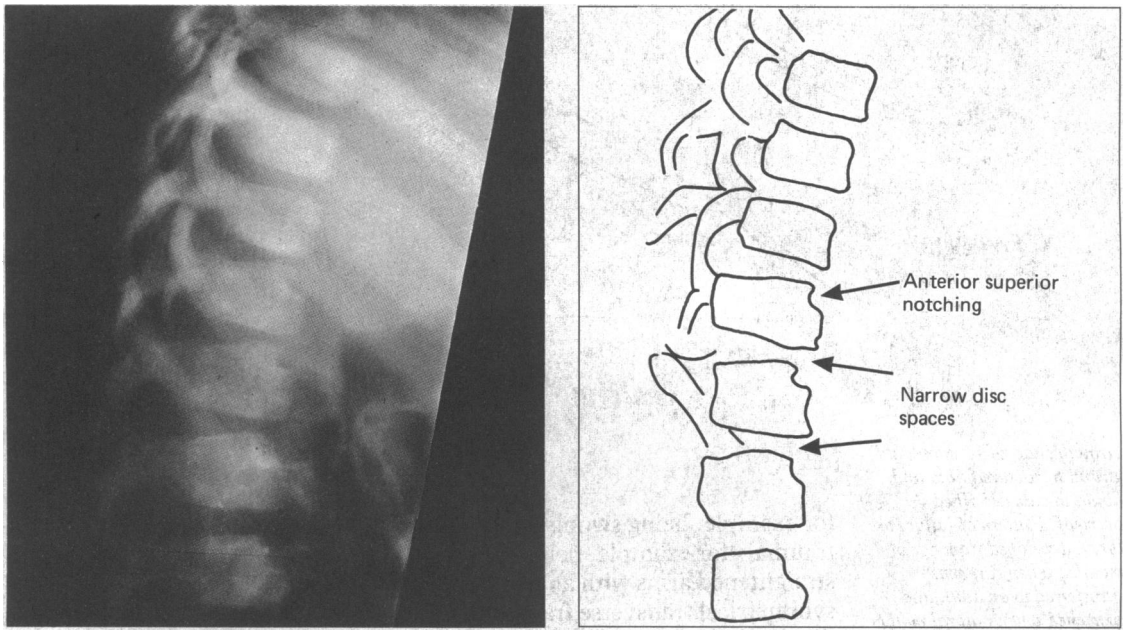
Repetitive injury to fractures that have not been medically treated may prolong the healing stages. Infants tend to heal more quickly than older children. Refracture through an old untreated fracture can be recognised by the presence of well developed callus around a fresh fracture with a clearly visible fracture line.

Differential diagnosis of fractures

Child abuse is common. Non-traumatic causes of fracture or pseudofracture vary from uncommon to extremely rare. A balanced perspective is required if children's interests are to be preserved. Courts for the protection of



Distal humerus epiphysial separation in 5 month old infant with 25 separate non-accidental injuries, including five fractures. Initially injury was confused with dislocation but on follow up four weeks later extensive formation of medial new bone (right) confirmed displacement of epiphysis



Spinal injury in abused 6 year old child. Characteristic injury is present

children require probability rather than certainty in evidence.

Normal variants—The formation of new periosteal bone in infants and unusual suture lines on a skull radiograph could be normal variants.

Birth trauma—During breech deliveries the clavicle and humerus are often broken. If, however, callus is absent two weeks after birth the fracture did not occur during delivery.

Bone disease—Osteogenesis imperfecta, rickets of prematurity, disuse osteoporosis, copper deficiency, Caffey's disease, and osteomyelitis can cause fractures and need to be excluded. Features in the history and examination, however, help to exclude these uncommon conditions. Expert radiological, paediatric, and biochemical help may be needed in occasional cases. The presence of a normal skeleton radiologically is strongly against the diagnosis of genetic, metabolic, or bone disease. In Leeds over 10 years fewer than five cases of physical abuse have been confused with bone disease.

I thank Dr M F G Buchanan for his help and the staff of the Department of Medical Illustration, St James's University Hospital, Leeds, for their help with the illustrations.

Further reading

Kleinman PK. *Diagnostic imaging of child abuse.* Baltimore: Williams and Wilkins, 1987.

The ABC of Clinical Genetics will continue next week. The fourth article in this series, which has been edited by Professor Roy Meadow, will appear on 29 April.

ANY QUESTIONS

What are the important cardiovascular abnormalities seen in patients with hypercalcaemia secondary to primary hyperparathyroidism, and what precautions are advised before surgery of the parathyroid gland in these patients?

The principal cardiac abnormalities of hypercalcaemia are shortening of the QT interval in the electrocardiogram, arrhythmias including heart block and cardiac arrest,[1] and raised blood pressure. Other possible effects include coronary artery spasm, a direct depressant effect on the myocardium, and calcium deposition within myocardial cells. Hyperparathyroidism has been claimed to cause cardiac hypertrophy even in the absence of hypercalcaemia.[2] Serious cardiotoxicity seems to be unusual with hyperparathyroidism, but serum concentrations should be reduced before surgery if possible. Prompt surgical treatment may be needed for severe hyperparathyroidism. Saline infusion and diuresis are recommended before the operation, usually with medical treatment aimed specifically at reducing the serum calcium concentration.[3] Experimental evidence shows that nifedipine and verapamil may reduce serious cardiotoxicity induced by hypercalcaemia, but we do not know if this has been used in association with surgery for hyperparathyroidism.—D A CHAMBERLAIN, *cardiologist*, N J A VAUGHAN, *endocrinologist, Brighton*

1 Fisch C. Relation of electrolyte disturbances to cardiac arrhythmias. *Circulation* 1973;47:408-19.
2 Symons C, Fortune F, Greenbaum RA, Dandona P. Cardiac hypertrophy, hypertrophic cardiomyopathy, and hyperparathyroidism—an association. *Br Heart J* 1985;54:539-42.
3 Wang C, Guyton SW. Hyperparathyroid crisis. *Ann Surg* 1979;190:782-90.